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Leg Telangiectasia Treatment With a 1.5 ms Pulsed Dye Laser, Ice Cube Cooling of the Skin and 595 vs 600 nm: Preliminary Results

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Background and Objective: **Preliminary results indicate that pulsed dye lasers (PDL) with 1.5 ms pulsewidth and 595 nm wavelength are effective in the treatment of leg telangiectasia. The aim of this study was to evaluate if the clinical results could be improved by a) an effective skin cooling with ice cubes and b) the longer wavelength of 600 nm.**
Study Design/Materials and Methods: **In 87 patients with vessels up to 1 mm in diameter, 257 single test treatments were performed using wavelengths of 595 and 600 nm, fluences of 16, 18, and 20 J/cm^2, a 1.5 ms pulse duration, and an elliptical spot of 2 × 7 mm. In 7 patients, the skin surface temperature curve was measured after cooling with ice cubes vs hydrogel dressings, and spot geometry and fluence were investigated with and without the gel dressing.**
Results: **Vessel clearance was evaluated 6–8 weeks after treatment. 20 J/cm^2 were most effective (80% clearance >50%), and 18 J/cm^2 were more effective than 16 J/cm^2 (66.2 vs 52.5% clearance >50%). There was a tendency towards better results with 595 nm, but the differences were not significant. Vessels with a diameter <0.5 mm cleared significantly better than those with 0.5–1 mm (69.1 vs 31.9% clearance >50%). Hypo- and hyperpigmentation were seen in 32% of the patients. Cooling with ice cubes proved to be far more effective than with hydrogel dressings (temperature decrease approx 15 vs 5°C). Additionally, the gel dressing caused an energy loss of approx 35% and an irregular spot geometry as shown on burn paper.**
Conclusions: **Treatment of leg telangiectasia with the 1.5 ms-PDL is safe and effective, especially in vessels smaller than 0.5 mm in diameter; 595 nm and 18 J/cm^2 seem to be somewhat more effective as 600 nm and 16 J/cm^2; and 20 J/cm^2 are even more effective, but persistent hyperpigmentation cannot yet be excluded due to insufficient follow-up time. Cooling with ice cubes is more effective and less expensive than gel dressings, and the short term clinical results are equivalent, even if the frequency of transient pigmentary changes is increased. Lasers Surg. Med. 23:72–78, 1998. © 1998 Wiley-Liss, Inc.**

Key words: flashlamp-pumped pulsed dye laser; long pulse dye laser; skin surface temperature; 1.5 ms-pulsewidth

INTRODUCTION

The pulsed dye lasers (PDL) with 450 μs pulsewidth and 585 nm wavelength represent the therapy of choice for port wine stains (PWS) and

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are an established therapeutic modality for other vascular skin lesions like telangiectasia of the face and neck, spider nevi, and hemangiomas of infancy. Nevertheless, according to the theory of selective photothermolysis and the optical properties of skin and blood, neither the pulselength of around 0.5 ms nor the wavelength of 585 nm are suited for larger caliber vessels >0.1 mm in diameter. This has been proven histologically [1] and is clinically confirmed by the fact that large-vessel-lesions like tuberous PWS and leg telangiectasias do not respond well to this kind of laser treatment [2–4].

Above 585 nm, the absorption coefficient of hemoglobin decreases rapidly. Light of these wavelengths can therefore penetrate more deeply into blood, thus enabling the homogenous heating of larger vessels [5], provided that the applied energy density is sufficient for thermal destruction of the endothelium. Additionally, for an optimal selective photothermolysis, the pulselength should equal the thermal relaxation time (τ) of the target structure [6]. The τ of 0.3 mm vessels is around 45 ms [7]. Therefore, for the treatment of leg telangiectasia, Kienle and Hibst postulate pulsewidths as long as technically possible in the 10 ms-range and wavelengths longer than 585 nm [7].

Recently, new PDL machines with adjustable wavelengths between 585 and 600 nm and a pulsewidth of 1.5 ms became available with spot sizes of up to 7 mm (circular) or of 2 × 7 mm (elliptical). Regarding the wavelength and the elliptical spot size, these lasers fulfill the theoretical postulations of Kienle and Hibst [7], the pulsewidth, however, is not yet optimal. In a first clinical study with these PDL [8], leg vessels were treated with 595 nm through a transparent hydrogel dressing applied for epidermal cooling. The results were encouraging. Our preliminary investigations (see following section) had shown that irradiation through the gel dressing leads to an energy loss of around 35% and to a defocused spot on the skin due to scattering. Additionally, previously published results had demonstrated a good effectivity of direct skin cooling for laser treatment of ectatic vessels [9]. The aims of our study therefore were a) to evaluate 595 vs 600 nm in direct comparison and b) to evaluate whether direct cooling of the skin with ice cubes instead of gel dressings might improve the clinical results.

MATERIALS AND METHODS

For all investigations and treatments, a flashlamp-pumped pulsed dye laser (Sclerolaser plus™, Candela Corp., Wayland, MA) was used with an elliptical spot size of 2 × 7 mm, a pulsewidth of 1.5 ms and wavelengths of 595 or 600 nm.

Preliminary Investigations

Energy measurements were performed with an Ophir 30A-P-SH power meter (Ophir Optronics, Israel). Ten pulses with an energy density of 18 J/cm^2 were first measured without and then through a transparent hydrogel dressing (Vigilon™, Bard Inc., Murray Hill, NJ) that was applied over the power meters sensor surface. Compared to the direct irradiation (mean 1.83 J/pulse, *SEM* 0.02), the gel dressing reduced the transmitted energy by 35% (mean 1.19 J/pulse, *SEM* 0.1).

The geometry of the elliptical spot was likewise investigated using burn paper and 13 J/cm^2. When irradiated through the gel dressing, the formerly clear elliptical spot was defocused and showed irregular outlines and irregularities in the spot hinting at inhomogenities of the beam due to scattering effects (Fig. 1).

Skin Surface Temperature Measurements

The time-dependent decrease of skin surface temperature was measured in seven patients, comparing ice cubes with gel dressings (Vigilon™). Copper/constantan thermocouple needles connected with a Fluke 51 thermometer (Fluke MFG, Everett, WA) were directly applied to the skin without pressure. The temperature was measured before and immediately after applying the cooling and registered for 150 seconds. For ice cooling, a skin area on the thigh measuring approx 10 × 10 cm was rubbed with an ice cube for about 15 seconds without drying. For the hydrogel cooling, the dressing was refrigerator cooled (4°C) and applied directly to the skin of the opposing thigh with the probe in place. The temperature decrease was registered every 5 seconds for the first minute and then every 30 seconds. Means and *SEM*'s were computed and plotted using the GraphPad Prism™ software (GraphPad Software, San Diego, CA) (Fig. 2).

Treatment and Evaluation

All patients had telangiectasias of the legs and volunteered for the test treatments after undersigning informed consent. Intensively suntanned or dark pigmented skin (skin types IV and V), skin lesions in the treatment area, severe venous insufficiency, and perforator insufficiencies near the treatment areas (as excluded by doppler sonography) were exclusion criteria for treat-

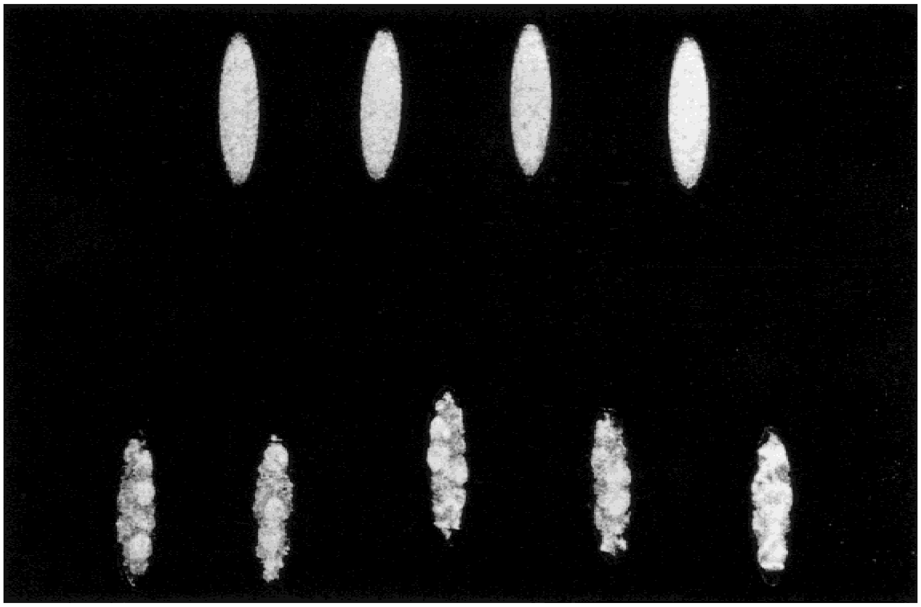

Fig. 1. Spot geometry without (upper row) and with (lower row) Vigilon™ (Bard Inc., Murray Hill, NJ) dressing at 13 J/cm². Note irregular intensity and outline of the spots in the lower row.

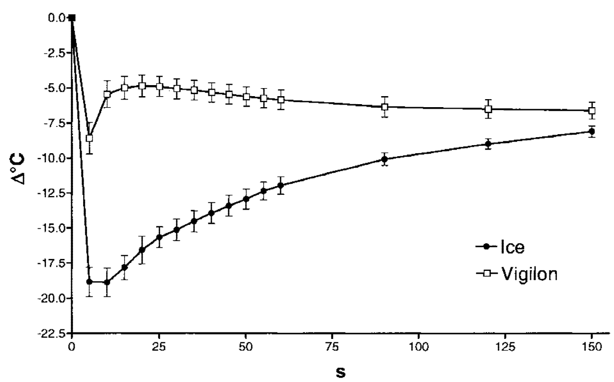

Fig. 2. Skin surface temperature measurements with ice and Vigilon™ (Bard Inc., Murray Hill, NJ). The error bars give the *SEM*.

ment. The presence of feeder vessels (e.g., reticular veins), if sonographically of no hemodynamic significance, was no exclusion criterion for this study and they were not treated by sclerotherapy before the laser treatment.

The test treatments were performed after cooling the skin approx 15 seconds with an ice cube and leaving the skin surface moist. After approx 1–2 minutes, the cooling procedure was repeated if necessary. The elliptical spots were placed along the vessel axis without overlapping.

The irradiation parameters (Sclerolaser plus™) were as follows: elliptical spot size 2 × 7 mm, 1.5 ms pulse duration, 595 or 600 nm wavelength and fluences of 16 or 18 J/cm². After the application of 18 J/cm² had proven reasonably safe, 20 J/cm² were additionally evaluated in a small group of recently treated patients. Routinely, no dressing or ointment was recommended after therapy. For crusts or blisters, an ointment containing gentamicin was prescribed.

The treatment areas were photodocumented before and 6 weeks after treatment at the time of evaluation. The vessel calibers were measured using a Delta 10 dermatoscope with a mm-scale (Heine, Germany).

The treatment was evaluated comparing the pretreatment photographs with the remaining vessels after 6, maximally 8 weeks. The results were classified as *excellent* (>95% clearance), *good* (50–95% clearance), *moderate* (10–50% clearance) and *poor* (<10% clearance).

All statistical evaluations were performed using the GraphPad Prism™ software (until otherwise stated, Fisher's exact test, two-sided, confidence interval 95%).

RESULTS

Effectivity of Skin Cooling

Figure 2 shows the temperature curves measured with the two different cooling methods. With the ice cube, the cooling proved to be far more effective (5 vs 15°C temperature decrease for approx 1 minute).

TABLE 1. Detailed Results (in %) of 257 Test Treatments, Grouped by Fluence, Wavelength, Vessel Diameter, and Localisation

Treatment Parameters and Vessel Caliber	Excellent	Good	Moderate	Poor
20 J/cm², 595 nm, –0.5 mm, n = 9	11,1	77,8	11,1	—
20 J/cm², 595 nm, –1.0 mm, n = 4	—	50	50	—
20 J/cm², 600 nm, –0.5 mm, n = 8	12,5	87,5	—	—
20 J/cm², 600 nm, –1.0 mm, n = 4	—	50	50	—
20 J/cm², all parameters, n = 25	8	72	20	—
18 J/cm², 595 nm, –0.5 mm, n = 32	15,6	68,7	12,5	3,2
18 J/cm², 595 nm, –1.0 mm, n =17	—	41,2	35,3	23,5
18 J/cm², 600 nm, –0.5 mm, n = 18	27,8	50	22,2	—
18 J/cm², 600 nm, –1.0 mm, n =7	—	14,3	57,1	28,6
18 J/cm², all parameters, n = 74	13,5	52,7	24,3	9,5
16 J/cm², 595 nm, –0.5 mm, n = 63	7,9	60,4	20,6	11,1
16 J/cm², 595 nm, –1.0 mm, n = 19	—	26,3	52,6	21,1
16 J/cm², 600 nm, –0.5 mm, n = 58	8,6	43,1	43,1	5,2
16 J/cm², 600 nm, –1.0 mm, n = 18	—	27,8	38,9	33,3
16 J/cm², all parameters, n = 158	6,3	46,2	34,8	12,7
595 nm, –0.5 mm, all fluences, n =104	10,6	64,4	17,3	7,7
595 nm, –1.0 mm, all fluences, n = 40	—	35	45	20
595 nm, all parameters, n = 144	7,6	56,3	25	11,1
600 nm, –05 mm, all fluences, n = 84	13,1	48,8	34,5	3,6
600 nm, –1.0 mm, all fluences, n = 29	—	27,6	44,8	27,6
600 nm, all parameters, n = 113	9,7	43,4	37,2	9,7
–0.5 mm, all parameters, n = 188	11,7	57,4	25	5,9
–1.0 mm, all parameters, n = 69	—	31,9	44,9	23,2
Thigh/knee, all parameters, n = 187	9,1	44,9	32,1	13,9
Calf/ankle, all parameters, n = 70	7,1	48,6	32,9	11,4

Clinical Results

There were 257 treatments from 87 patients that could be evaluated. With all parameters used, vessels larger than 1.0 mm in diameter never showed any clinical lightening. Therefore, these vessels were not further treated after the first discouraging results and are not included in this study.

Table 1 presents the detailed results for 16, 18, and 20 J/cm², the different wavelengths, the vessel diameters, and the locations: thighs and knee vs calves and ankles. First, it shows that the effectivity of the therapy clearly depends upon the applied fluence. The percentages of clinically satisfying results (> 50%-clearance) decrease from 80% for 20 J/cm² to 66.2% for 18 J/cm² and to 52.5% for 16 J/cm² (Table 1). The difference between the lower fluences is not significant ($P = 0.064$), but 20 J/cm² are significantly more effective than the two lower fluences ($P = 0.03$).

When the 600 nm-wavelength is compared to 595 nm, there seems to be a tendency toward a better rate of excellent results for 600 nm, but the overall percentages of clinically relevant lightening (> 50%-clearance) are better with 595 nm, even if the difference is not significant (Table 1, > 50%-clearance rates 63.8% for 595 nm, 53.1% for 600 nm, $P = 0.096$). An exception is the 20 J/cm²-group, where the > 50%-clearance is slightly better with 600 nm, but the numbers in this group are very small. Even in the subgroup of the larger vessels of 0.5 to 1.0 mm, the 600 nm-wavelength was inferior to 595 nm (Table 1, > 50%-clearance 27.6% vs 35%, $P = 0.60$, not significant).

The most important prognostic factor for the result is the vessel diameter, as Table 1 also shows. Smaller vessels up to 0.5 mm in diameter have a better > 50%-clearance rate of 69.1% than the larger vessels with only 31.9% ($P < 0.0001$). Excellent results can only be achieved in the thin-vessel-group (11.7%), but not with larger vessels (Table 1).

The localisation of the telangiectasias proved to be of no significant influence on the results

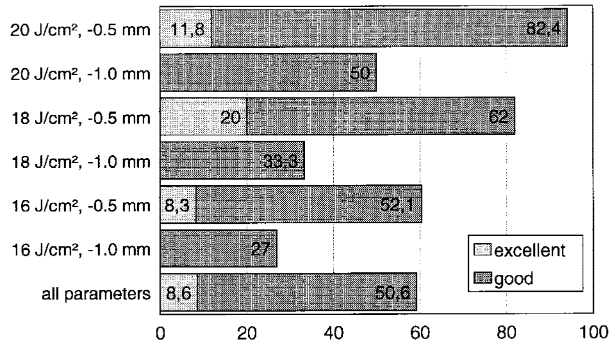

Fig. 3. Excellent and good results according to fluence and vessel diameter, both wavelengths, and overall results of 257 treatments.

(Table 1, $P = 0.88$). The > 50%-clearance rate of 54% in thigh or knee lesions is absolutely comparable to that of 55.7% in calf or ankle lesions.

Figure 3 shows the percentages of excellent and good results achievable with both wavelengths in the subgroups of different fluences and vessel diameters together with the overall results (all parameters, all vessels). Satisfying results, that is, a clearance of > 50%, can be achieved in approx 80–90% of vessels smaller than 0.5 mm in diameter and in approx 30–50% of vessels up to 1 mm with fluences of 18–20 J/cm^2.

Complications

The main side effects were hypo- and hyperpigmentation, which presented in an equal frequency of 32% in all test treatments. In all those patients that were seen in the follow-up visits for further treatment, the pigmentary changes were reversible and had resolved after 3–6 months. Since the treatment with 20 J/cm^2 was introduced only recently, the resolution or persistence of pigmentary changes in these patients can not yet be definitely evaluated. Nevertheless, in the first few patients who most recently completed 6-month follow-up visits, the pigmentation had also resolved completely. Complications like posttreatment blistering and crusting were infrequent according to the patients. Persisting side effects like atrophy or scarring were not seen except in one patient, where the pulses had been falsely placed too close together resulting in a slightly atrophic and hypopigmented scarring in a 4 × 5 cm area.

The frequency of hyperpigmentation was clearly dependent from the applied energy density. With 16 J/cm^2, it was 22.1%, with 18 and 20 J/cm^2, it increased to 47.3 and 48%, respectively (significant with the χ-square-test, $P = 0.029$). Interestingly, in patients with a good clinical result (clearance > 50%, $n = 152$), the frequency of hyperpigmentation is higher (38.8%) than in the group with < 50%-clearance (20.0%, difference significant, $P = 0.0016$). Surprisingly, the frequency of hypopigmentation was lower in the high-energy groups (20 J/cm^2: 16%, 18 J/cm^2: 21.6%) compared to 39.2% in the low-energy group.

DISCUSSION

Larger vessels, like in PWS of adults, tuberous PWS, or in leg telangiectasia (except the very small, bright red variety), cannot be treated sufficiently by the 450 μs-flashlamp-pumped pulsed dye laser at 585 nm (FPDL) [2–4,10]. According to the theory of selective photothermolysis [6] as well as the given optical properties of skin and blood [11], this is due to the short pulselength (which should optimally be in the 10 ms-range) and the high hemoglobin absorption and consecutively low blood penetration depth at 585 nm. Although far from ideal in the realm of pulse duration, the long-pulse, flashlamp-pumped tunable dye laser (LPTDL) with 1.5 ms-pulses and wavelengths between 585 and 600 nm promises more clinical efficacy in large-caliber vessels [5,7].

First clinical results with this laser were presented by Hsia et al. [8]. They performed leg telangiectasia treatments with 595 nm through Vigilon™, a transparent hydrogel dressing applied for epidermal cooling. For vessels up to 1.067 mm diameter and 18 J/cm^2, they reported a > 50%-clearance rate of 45.2% by 6 weeks and of 64.7% by 5 months after treatment.

In our study, we wanted to evaluate whether the 600-nm-option of the Sclerolaser plus™ with its deeper penetration in blood, even if due to lower absorbance in hemoglobin, might be of advantage in the treatment of leg vessels, especially of larger caliber. Since our preliminary investigations had shown that irradiation through the hydrogel dressing with its somewhat granular structure leads not only to the loss of the exact spot geometry (Fig. 1) but also to an energy loss of approximately 35%, we decided to use ice cubes for skin cooling.

Our results demonstrate that the LPTDL is effective in the treatment of leg vessels. A satisfactory clinical result, i.e., a clearance of over 50%, could be achieved in 59.2% of the 257 test areas treated in leg vessels up to 1 mm in diameter (Fig. 3). With the most effective treatment

parameter of our study, that is, with 20 J/cm^2, an > 50%-clearance rate of 80% can be achieved in telangiectasias up to 1 mm in diameter (Table 1), with 18 J/cm^2 and 595 nm, the > 50%-clearance rate is approx 75%. Nevertheless, the success is clearly dependent upon the vessel caliber: the overall, > 50%-clearance rate decreases from 69% (diameter $\leqslant$ 0.5 mm) to 32% (0.5 to 1.0 mm).

The higher fluences of 18 and 20 J/cm^2 are more effective for clearance but show an increased rate of hyperpigmentation. We cannot quite explain the fact that hyperpigmentation developed much more frequently in patients with good clinical lightening of their telangiectasias. Perhaps the inflammatory reaction leading to consecutive stimulation of melanogenesis is more pronounced when a vessel is destroyed completely. To investigate the exact reason, posttreatment biopsies could possibly be helpful, but none of our patients consented to this. The fact that the higher energy produced less hypopigmentation than the lower one is probably due to a patient selection bias: Most patients with suntanned skin were treated with 16 J/cm^2 only in fear of epidermal blistering, so the rate of patients with tanned skin and hence a higher risk of hypopigmentation was larger in the 16 J/cm^2-group.

The treatment with 600 nm was not quite as effective as with 595 nm, although the difference was not significant. Even in the large-caliber-vessel group, where, according to theory, the longer wavelength might be better [5], the results showed not only no benefit for 600 nm, but better clearance for 595 nm, as well (Table 1). Most probably the reduced absorption in hemoglobin at 600 nm, together with the relatively short pulselength of 1.5 ms, lead to an insufficient transfer of thermal energy that is not able to destroy the vessel walls. For utilization of the theoretical advantages of wavelengths $\geqslant$ 600 nm, i.e. their deeper penetration and thus their ability to reach the lower side even of large-caliber vessels, longer pulselengths in the 10 ms-range probably become necessary [7].

Hsia et al. presented a > 50%-clearance of 43.6% (n = 13) after 6 weeks in 0.6–1.1 mm-vessels treated with 18 J/cm^2 and 595 nm. Side effects in this group were hyperpigmentation in 31% and hypopigmentation in 15%, both reversible [8].

In the comparable group of our study (0.5–1.0 mm vessels, 18 J/cm^2, 595 nm, n = 17) the result was nearly identical with a > 50%-clearance of 41.2%. The rate of transient pigmentary changes was higher in our study, probably due to the higher fluence on the skin that resulted from our omission of the gel dressing that otherwise absorbs and disperses approx 35% of the irradiated energy. Referring to surface temperature, the ice cooling method proved more effective than precooled gel dressings (Fig. 2), but could not prevent an increased rate of hyperpigmentation with these higher fluences.

Hsia et al. stated the fact that after 5 months, the clinical results were further improved without repeated treatments [8]. Unfortunately, we cannot present long term results of the test areas, since the patients volunteering for the study and who showed some degree of clearance understandably insisted on further laser treatment at the time of the first follow-up (6–8 weeks) and therefore were retreated. The long-time results of repetitive treatments of larger areas are currently under investigation and will be presented at a later stage.

CONCLUSIONS

The LPTDL is safe and effective for the treatment of leg telangiectasias, especially for vessel diameters up to 0.5 mm. Even if not statistically significant, 595 nm seem more effective than 600 nm, and higher fluences (18 and 20 J/cm^2) are more effective, even if connected with an increased rate of transient pigmentary changes.

Cooling with ice cubes is more effective in terms of surface temperature and markedly less expensive than with hydrogel dressings. Pigmentary changes are somewhat more frequent with this method, but were reversible in all cases with a follow-up of 3–6 months.

With 18 and 20 J/cm^2, a clinically reasonable clearance (> 50%) of leg telangiectasias $\leqslant$ 1 mm in diameter can be achieved with one single treatment in approx 65 to 80% of the patients, respectively. Even without retreatment, further improvement possibly can be seen after some months. Repeated treatments, like in sclerotherapy, should lead to consecutively better results, and a combination with sclerotherapy of the reticular veins (“feeder vessels”) as a first step may render the laser therapy even more effective.

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